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Brief communication

Modified liquid entrainment fraction correlation for varying pipe orientation and system pressure

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Review

Cioncolini and Thome (2012) proposed a correlation to predict the liquid entrainment fraction in vertical upward gas–liquid annular two phase flow. Their correlation is based on a two-step method of predictor and corrector technique. This technique calculates an approximate value of liquid entrainment fraction in the first (predictor) step and then recalculates its corrected value in the second (corrector) step. In the predictor step, as shown in Eq. (1), the predicted value of gas core Weber number ($We_{c,p}$) is calculated using gas density (ρ_G) [kg/m^3], superficial gas velocity (U_{SG}) [m/s], pipe diameter (D) [m] and the gas–liquid interface surface tension (σ) [N/m]. Based on this predicted Weber number, the first estimate of liquid entrainment fraction (E_p) is calculated from Eq. (2) where the multiplying factor (ξ) of 279.6 and exponents of −0.8395 and −2.209 are determined from the experimental data for vertical upward flow by solving for a nonlinear regression problem and are based on least absolute residuals. Next, the gas core density (ρ_c) [kg/m^3] based on two phase flow quality (x) and the gas and liquid phase density (ρ_G and ρ_L) is calculated using E_p in Eq. (3) and the corrected values of gas core Weber number (We_c) and liquid entrainment fraction (E) are calculated in Eqs. (4) and (5), respectively.

$$We_{c,p} = \frac{D\rho_G U_{SG}^2}{\sigma} \tag{1}$$

$$E_p = \left(1 + \xi \times We_{c,p}^{-0.8395}\right)^{-2.209} \quad \text{where } \xi = 279.6 \tag{2}$$

$$\rho_c = \frac{x + E_p(1-x)}{(x/\rho_G) + E_p(1-x)/\rho_L} \tag{3}$$

$$We_c = \frac{D\rho_c U_{SG}^2}{\sigma} \tag{4}$$

$$E = \left(1 + \xi \times We_c^{-0.8395}\right)^{-2.209} \quad \text{where } \xi = 279.6 \tag{5}$$

The correlation of Cioncolini and Thome (2012) is based on the experimental data set consisting of 2293 data points for circular pipes and 71 data points for non-circular pipes in vertical upward flow. Their correlation also used 96 data points in horizontal two phase flow for preliminary comparison and to validate their correlation (based on data in vertical upward two phase flow). For horizontal flow, Cioncolini and Thome (2012) found a significant scatter between the measured data and the predicted values however; they concluded that the general trend of the liquid entrainment in horizontal flow was correctly captured by their correlation.

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